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14. ABSTRACT
This document is prepared for the final report of the instrumentation acquisition grant received from army research. We sincerely appreciate your support for this effort. In the report we summarize the cost items associated with this acquisition and the project being conducted and planned.

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Report Title

Final Report: Instrumentation Acquisition for Research and Education in Additive Manufacturing and Advanced Material Fabrication

ABSTRACT

This document is prepared for the final report of the instrumentation acquisition grant received from army research. We sincerely appreciate your support for this effort. In the report we summarize the cost items associated with this acquisition and the project being conducted and planned.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Post Doctorates

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Faculty Supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

Technology Transfer

Contract Title: Instrumentation Acquisition for Research and Education in Additive Manufacturing and Advanced Material Fabrication

Contract number: W911NF-14-1-0083

Date: May 135h 2015

This document is prepared for the final report of the instrumentation acquisition grant received from army research. We sincerely appreciate your support for this effort.

1. Equipment items purchased:

	Name of the equipment	Manufacturer	Cost	Description
1	**Renishaw AM 250 Selective Laser Melting Machine**	Renishaw	$585,305	This vendor was selected for purchase due to lower acquisition cost and better machine features
2	**Accessory of the AM 250:**			
	• AutoFab R&D File Preparation Software		$ 19,500	
	• Ruwac Immersion Separation Vacuum System		$10,000	
	• Chiller HRS024-AN-20-T		$5,000	
	• Sieving Station		$ 22,400	
	• AM250 Materials Module		$ 10,365	
	• AM Powder (SS 316L) 60Kg		$ 7,152	
	• AM Accessories Tool Kit		$ 2,390	
	• AM250 Steel Sign-Off Kit		$ 1,430	
	• Powder Change Kit		$4,961	
	• Safe Change Filter Housing		$ 9,147	
	• Powder Flask Kit		$2,582	
3	**Machine Operation and Processing Training**		$ 6,400	
4	**Advanced Materials Training**		$ 12,800	
5	**Installation**		$0	Installation fee is covered in the package
6	**2 years warranty**		$0	Free for the first two years
	Total Cost before deduction of cooperative funding		$699,432	
	Cooperative Funding for Business Development Partnership		($211,432)	Industry grant provided by Renishaw which is used to cover part of the total cost
	AM250 Net Package Price Including Cooperative Funding		$488,000	This is the final amount paid for acquisition of the equipment.

2. Summary of projects supported by the equipment:

<u>Research Projects:</u>

Currently research project supported by the equipment

1. ***Pilot study of selective laser melting of Tefenol – D giant magnetostricitve material***. Terfenol-D has the advantage of achieving magnetostriction comparable to Terfenol, but at a much lower applied magnetic field. It has been used for a wide variety of applications, including sonar transducers, sensor and actuators. A study of laser melting of Terfenol-D was conducted recently by the research team, which shows very promising results. Conclusions are made at this stage, based on these SEM observations:
   - Terfenol-D can be melted using the SLM process, over a quite large range of process parameters.
   - Cracking exhibited on the top surface is likely due to rapid cooling, large powder size, poor powder distribution and the resulting internal stress.
   - Overlapping of hatch lines can remelt the material, which flows into and fills the cracks.
2. ***Study of selective laser alloying***:
   The objective of this project is to study the laser alloying process and its impact to the selective laser melting process. Currently, experimental research is being conducted to study laser alloying of Titanium and Boron pure elements. It was observed that at low energy density level, reaction of Ti and B was initiated, which in turn assisted the melting process. This can be used to reduce the energy requirement of the SLM process and greatly increase the speed of the printing process.
3. ***Selective Laser melting of Metastable alloys***
   The objective is to investigate the impact of metastable alloys to the SLM process. Currently, AlFe metastable alloy powders were created using mechanical alloying process and was then printed with the machine. It is observed that metastable powders can be melted and printed at lower power and faster speed. Further research work is planned to model the energy saving of the metastable powders in SLM.
4. ***Biocompatibility study of SLM printed stainless steel implant***:
   The objective of this research is to investigate implant printed by SLM machine and its impact to the bio properties. Samples are printed and test will be conducted in summer 2015.
5. ***Selective Melting of Nitinol:***
   The objective of this research is to print Nitinol and investigate its application in bio implant and aviation.

Planned research:

1. Hierarchical material design and fabrication: the research team plans to design and synthesize sophisticated microstructures for dense hierarchical materials. The team is also interested in design and creating cellular solids using SLM for hierarchical cellular materials.
2. Material design and optimization: The equipment will also be used to develop a comprehensive understanding of the relationship between the property of the microstructure made by SLM and the bulk property of the material. The team will investigate typical micro/cellular/mesh/lattice structures with different geometry, scale, arrangement and their relationship to the property of the bulk material.
3. Smart materials/structures/devices: when the process parameters are controlled properly, SLM has potential to create microelectromechanical (MEMs) structures such as seniors, actuators or micromotors. Combined with capability of fabrication of fine structures and multi-material systems, SLM can create novel material that response to designed or external stimuli
4. Development of novel heat exchangers with 3D flow configurations

5. OmniScanning hybrid SLM for advanced surface quality and fabrication of microstrcucture
6. Experimental research on the joint effect of laser melting and laser erosion processes
7. Closed loop monitoring and control system to improve the consistency and repeatability of SLM

Education projects:

A new course MANE 6369 Advanced Additive Manufacturing Processes was created and offered in Spring 2015. The equipment served as the key lab equipment for this class. Training and workshops are provided in 2015 for design and innovation based on selective laser melting process.